ROOFTOP GARDEN-BASED EDUCATION: CULTIVATING A HEALTHY AND ENVIRONMENTALLY AWARE URBAN YOUTH

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Preface

Inspiration for this project came during a summer spent in New York City. Over the course of an 8-week internship stint, I began to feel a noticeable disconnect from the nature that I was used to interacting with in North Carolina. I became pessimistic about the ability for city-dwellers, particularly those who spent their entire lives in urban areas, to have a deep connection with or understanding of an environment that includes green space or food production.

However, two impactful events corrected this way of thinking. The first was a visit to Brooklyn Grange, the world's largest soil-based rooftop farm. A tour of their flagship location introduced me to an innvoative method of urban agriculture that works within the space contraints of a city to successfully produce locally-raised fruits and vegetables. During the visit, I learned about City Growers, the organziation that operates garden-based education programs on the farm. At the time, I was intrigued by the idea of garden-based education, but it wasn't until the fall of that year that I realized the impact that it had. As an intern for Sustain: the alliance for better food and farming in London, I assisted with the School Marketplace at City Hall where students proudly sold produce they had grown in their school gardens. After talking to the young growers at the event, I realized the impact that garden-based education had as it allowed them to develop environmental awareness, nutrition knowledge, and important life skills.

Reflecting on these two experiences encouraged me to consider how a connection between rooftop growing and garden-based learning might positively impact cities and their young residents.

Introduction

Currently, 82.7% of the United States population lives in cities and this number continues to grow.[1] The practice of cultivating the land that defines the rural agrarian lifestyle and was once the norm has been replaced by an urban way of living, which involves interacting with a built environment of streets, buildings, and other human-made infrastructure. A large majority of the 73.9 million children in the United States are among those carrying out these modern lifestyles.[2] Rather than having frequent exposure to vast natural landscapes, more and more children are spending their formative years navigating the concrete blocks of cities and occasionally public parks or man-made green spaces. The life experiences that the urban youth face shape their unique worldviews, which are distinct from those of their rural and suburban counterparts.

While disengagement from nature is a problem that children across the country face, children growing up in in cities have fewer opportunities to interact with natural settings. Their perception of the natural world has been defined by their experiences with urban nature, the green spaces that are a part of the built environment. This lack of exposure to the natural environment often contributes to feelings of removal from environmental issues, which are prevalent among urban youth.[3] As a result of this and the overwhelming absence of

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[1] "Forecast on the Degree of Urbanization in the United States from 2000 to 2050," accessed February 22, 2019, https://www.statista.com/statistics/678561/urbanization-in-the-united-states/.

[2] "Child Population: Number of Children (in Millions) Ages 0–17 in the United States by Age, 1950–2017 and Projected 2018–2050," ChildStats.gov: Forum on Child and Family Statistics, accessed April 1, 2019, https://www.childstats.gov/americaschildren/tables/pop1.asp.

[3] Anastasia Cole Plakias, *The Farm on the Roof: What Brooklyn Grange Taught Us About Entrepreneurship, Community, and Growing a Sustainable Business* (New York: Penguin Random House, 2016).

environmental education programs in schools, these children grow up with limited awareness of the environment.

Similarly, children growing up in cities are not likely to engage with local, sustainable food systems. They are farther removed from food growing than children who grow up in suburban, and particularly in rural, areas. For the most part, the pre-consumption interactions that the urban youth have with their food take place in convenience stores that primarily sell highly processed foods riddled with sugar and salt. In effect, children, who develop food preferences based on familiarity, are conditioned to make unhealthy food choices.

Together, this limited awareness of both the environment and food systems that 82.7% of the population faces is particularly problematic given the circumstances of today. The environmental degradation related to human behavior has resulted in climate change, air and water quality issues, and ozone depletion in addition to countless others. This problem, which greatly impacts the earth's ability to sustain the human population, necessitates more environmentally conscious human actions. Children growing up in cities need to be taught about these environmental issues such as climate change, pollution, and resource depletion so that they may understand that they are both directly influenced by them and that their actions can directly perpetuate them.

In addition to the environmental crisis that exists today, childhood obesity is at an all-time high. It impacts children in the United States at a rate of 18.5%, which translates to about 13.7 million children who are affected by the disease.[4] The side effects adversely influence physical, social, and mental well-being, which results in overall reduced quality of life. Furthermore, the epidemic significantly affects the national economy as it leads to billions of

[4] Craig M Hales, "Prevalence of Obesity Among Adults and Youth: United States, 2015–2016," no. 288 (2017): 8.

dollars in healthcare, transportation, productivity, and human capital costs.[5] Although childhood obesity is caused by complex interactions between genetic and environmental factors, diet plays the most significant role in promoting the disease. In order to encourage better food choices and improve the diets of children, nutrition education should be improved and more widely implemented. As food activist Alice Waters has stressed, "We need to bring children into a positive relationship with food, starting when they are very young, so that they fall in love with fruits and vegetables and Mother Nature."[6]

Garden-based learning, which encompasses all activities in which the garden is the foundation for integrated learning across disciplines, has the potential to address both issues.[7] There is a wide body of research that points to the success of garden-enhanced education in promoting healthier diets and environmental awareness. Additionally, gardening has profound benefits on academic, social and mental health outcomes of those that engage with it. Educational garden programs can also strengthen the community in the schools or neighborhoods in which they are based by involving local volunteers and organizations.[8]

Garden-based learning programs are particularly powerful in educating urban youth, who are rarely given the opportunity to interact with food systems. They provide a multidimensional learning opportunity for them to bridge the gap between the abstract concept of the "environment" and their own immediate surroundings. Engagement with gardens facilitates the

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[5] Ross Hammond and Ruth Levine, "The Economic Impact of Obesity in the United States," *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy* 3 (2010): 285–95, https://doi.org/10.2147/DMSOTT.S7384.

[6] Kyle Cornforth, "The Edible Schoolyard: How It Works and Lessons for Parents, Teachers, and Health Professionals," *Childhood Obesity; New Rochelle* 7, no. 4 (August 2011): 278–81, http://dx.doi.org.libproxy.lib.unc.edu/10.1089/chi.2011.0400.expt.

[7] Aarti Subramaniam, "Garden-Based Learning in Basic Education: A Historical Review," Summer 2002, https://littlegreenthumbs.org/wp-content/uploads/2018/02/GardenBasedLearninginBaseicEducation_4H.pdf.

[8] "Food Growing in Schools Taskforce" (Garden Organic, March 2012), https://www.foodgrowingschools.org/resources/files/FGIS%20main%20report%20for%20www.PDF.

active processing of information and generates long-lasting benefits. However, developing these programs requires overcoming several challenges that include funding, staffing, time, and space.[9] In urban areas specifically, access to the space required to build school gardens presents a significant barrier. Both the limited availability and the high costs of land are two major deterrents for building out these programs. In the country's largest and most developed cities like New York, Los Angeles and Chicago, the land is simply too expensive to make school gardens widespread.

Rooftops offer a unique and viable solution. Although ground-level space is extremely difficult to come by, space on top of buildings is widely available. In New York, for example, there are at least 3,000 acres of available rooftop space that is conducive to food growing.[10] If leveraged as sites for garden-based education programs, thousands of children and their communities may reap the positive benefits of hands-on learning, local produce, and additional green space. Additionally, through the positive effects they have on the environment, they would help address some of the environmental issues that are amplified in cities.

Thus, it is worth considering the current models for garden-enhanced learning programs and the ways in which they might fit into the current trend towards growing on rooftops. Analyzing the benefits and challenges of school gardens and how they correspond to those of the existing rooftop gardens provides valuable insights into how rooftop school gardens may be used to educate children growing up in cities in order to cultivate a healthier and more environmentally aware urban youth.

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[9] Ibid.

[10] Annie Novak, *The Rooftop Growing Guide: How to Transform Your Roof Into a Vegetable Garden Or Farm* (Ten Speed Press, 2016).

Chapter 1: Garden-Based Education Programs

Brief History

Garden-based learning has existed long before the modern emphasis that has been placed on experiential and naturalistic education. Though the widespread recognition of the benefits of school gardens is more recent, their ideology has a long history rooted in the writings of 17th-century philosophers. At the time known as "education according to nature," garden-based learning was identified as a tool for pragmatic and experiential education used to provide children with practical skills and a deeper understanding of the natural world.[11]

John Amos Comenius, a Czech philosopher regarded as the father of modern education, advocated for universal, innovative, and practical education practices. He wrote, "A school garden should be connected with every school, where children can have the opportunity for leisurely gazing upon trees, flowers, and herbs, and are taught to appreciate them."[12] About a hundred years later, Jean-Jacques Rousseau also emphasized the importance of natural education and taught that children should grow and study with the outdoor environment to protect and foster the development of their natural goodness.[13]

In 1774 Johann Heinrich Pestalozzi, who emphasized observation and activity in learning, started a school that incorporated gardening, farming, and home skills.[14] His student, Friedrich Froebel, expanded upon Pestalozzi's philosophies and founded the concept of kindergarten, which is translated literally as "child's garden." He taught that children "should be

[11] Leigh Klein, "Garden-Based Learning: A Look at Its Importance for Children" (M.A., Prescott College, 2012), http://search.proquest.com/docview/1021050377/abstract/DC3E0732B120472CPQ/1.
[12] Subramaniam, "Garden-Based Learning in Basic Education: A Historical Review."
[13] Ternan Monteiro, "Rousseau's Concept of Education," n.d., http://snphilosophers2005.tripod.com/ternan.pdf.
[14] Subramaniam, "Garden-Based Learning in Basic Education: A Historical Review."

aroused to activity by having their interest awakened, cultivated, unfolded and ripened."[15] He believed the garden plays a foundational role in encouraging this as it provides a hands-on learning experience that allows a child to draw connections between taught concepts and real things.

The Froebel Educational Institute was founded in 1884 in London with the purpose of training teachers in the educational ideas of Friedrich Froebel.[16] With this development, Froebel's educational theory became extremely influential to the British nursery school system and spread across many parts of Europe. As a result, the garden became an integral part of the British school environment and remains such today.

Shortly after school gardens began gaining traction in Europe, Henry Lincoln Clapp of the Massachusetts Horticulture Society traveled overseas to study them. After seeing and learning from Froebel's philosophies in practice, Clapp returned to pioneer garden-based education in the United States. He installed the first American school garden at George Putnam School in Roxbury, Massachusetts.[17] This launched a movement across the United States and by 1918, every state had at least one educational garden. After this initial movement, the popularity of school gardens ebbed and flowed until the turn of the century.

Although school gardens had successfully spread across the country by 1918, their educational value began losing attention. During World War I and World War II, there was a resurgence in school gardens along with the victory garden movement. School gardens were created out of necessity in order to address the food crisis that emerged as agricultural workers

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[15] Elizabeth S. Cole, "An Experience in Froebel's Garden," *Childhood Education; Washington* 67, no. 1 (Fall 1990): 18–21.

[16] This was the result of the success that kindergarten programs based on Froebel's philosophy had in London. These programs were introduced by a group of German teachers who immigrated to England after a failed Prussian revolution.

[17] Subramaniam, "Garden-Based Learning in Basic Education: A Historical Review."

were recruited into military service. The Federal Bureau of Education launched the U.S. School Garden Army during the first world war, which encouraged urban and suburban youth to garden in order to raise food for the nation. Though the Bureau recognized the educational benefits of school agriculture, their message focused on production as a form of patriotism and civic participation. In addition to increasing food production, the program sought to shape cultural values by encouraging citizenship through service. Unlike the gardens that were created in order to facilitate learning, these victory gardens were not fully incorporated into the formal curriculum.[18] Though it focused on the benefits of the nation rather than those of the individual students, the program contributed to the nationalization of agricultural education. However, once the war ended, the advancement of school gardens reached a standstill.[19]

It was not until the mid-1960s that the second wave of school gardens took place. It occurred in congruence with the "war on poverty" educational reform strategy and the progressive environmental movement. However, the momentum of the school garden once again slowed in the 1980s in part due to the conservatism that defined the period.[20]

The American Horticulture Society brought garden-based education back to local, state, and national agendas in 1993 by holding a symposium on youth gardening entitled, "Children, Plants, and Gardens: Educational Opportunities." Over the twenty-five years that have followed, school gardens have been used as a tool to educate more than one million children.[21] In the 2013-2014 Farm to School Census sponsored by the United States Department of Agriculture, 44% of school districts reported that they maintained gardens where children learn about how food

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[18] Rose Hayden-Smith, "Soldiers of the Soil: A Historical Review of the United States School Garden Army" (University of California Davis, Winter 2006), https://ucanr.edu/sites/thevictorygrower/files/101531.pdf.
[19] Subramaniam, "Garden-Based Learning in Basic Education: A Historical Review."
[20] Ibid.
[21] "National Children & Youth Garden Symposium," American Horticultural Society, accessed February 22, 2019, https://www.ahsgardening.org/gardening-programs/youth-gardening/ncygs.

grows. This number represents an increase of 42% from previous reports.[22] As a result of the growing number of school gardens, children across the country have reaped the many academic, physical, and emotional benefits of gardening.

Over the course of history, garden-based learning has had varying priorities. As the needs of children have changed over time, the curricula of these garden education programs have also shifted to address them. The early pioneers like Comenius and Froebel were primarily focused on developing a hands-on learning method that would promote higher-order thinking and further engage children in academic subjects like science, mathematics, and art. Today, as childhood obesity rates skyrocket and environmental degradation intensify, gardens are being leveraged as a tool for nutrition and environmental education.

Garden-Based Learning Programs Today

There is no universal garden-based learning curriculum nor one perfect example of what a school garden should look like. Rather, these programs take many forms across the United States in order to address the unique circumstances of each school environment. Among the more than 7,000 school gardens that exist across the country, there are raised beds in New York City, indoor tower gardens in Vermont, and school farms that span across acres in Minnesota.[23] In these various settings, children engage with activities like planting seeds, harvesting fruits and vegetables, composting, and even beekeeping. Furthermore, garden-based education programs exist both within schools and in informal education settings that are run by national and

[22] "Farm to School Works to Make Gardens Grow," The Farm to School Census, accessed February 22, 2019, https://farmtoschoolcensus.fns.usda.gov/farm-school-works-make-gardens-grow.
[23] Ibid.

community-based organizations such as FoodCorps[24] and City Growers. The leaders developing these programs also differ as they include teachers, school departments, parents, community partners, and national organizations. Although garden education programs are extremely diverse, they all share the common overarching goal of enriching the learning experiences of children.

To get a better sense of what the overlapping goals of these various programs are, it is helpful to analyze the missions and curricula of some of the most established and successful garden-based learning organizations in the United States. The Edible Schoolyard Berkeley, Grow to Learn NYC, and the Garden School Foundation in Los Angeles, all unique in their approach, serve as informative case studies.

The Edible Schoolyard Project

Alice Waters, a renowned food activist and owner of Chez Panisse, founded The Edible Schoolyard Project in 1995 with the goal of transforming children's relationships with food by allowing them to plant, harvest, and cultivate their own produce. She believes that teaching children how to feed themselves and how to live in a community responsibly should be at the center of an education.[25] Waters recognized the potential for applying this sort of education at Martin Luther King Jr. Middle School in her Berkeley, California neighborhood in 1995. At the time, the school was surrounded by vacant asphalt lots and did not have a functioning school cafeteria.[26] She worked closely with the school principal, Neil Smith, to transform a one-acre asphalt lot into the first edible schoolyard. With $10,000 in seed money, Waters and her team broke ground to create a teaching garden where students learn how to grow food, eat healthier,

[24] FoodCorps is a national non-profit organization that works with communities to create healthy school food environments by placing service members in limited-resource schools. They work to develop farm to school hands-on learning programs, healthy school meals, and a schoolwide culture of health.
[25] Ken Kelley, "Alice Waters," *Mother Jones*, 1995.
[26] Cornforth, "The Edible Schoolyard."

appreciate the beauty of a garden, and become stewards of the land.[27] The Edible Schoolyard Berkeley serves as an innovative model of a successfully integrated garden-based learning program.

The garden is fully integrated into the academic experience that Martin Luther King Jr. Middle School provides. Engaging science, humanities, and mathematics lessons are taught in the schoolyard, which allows students to make relevant connections to nature. Over the course of the three years that a student attends the school, they will have taken 60 classes in the program.[28] Additionally, the curriculum incorporates these lessons in a kitchen classroom where students learn how to prepare the fruits and vegetables that they grow.[29]

Ambassadors and advisory board members of the program include leading food activists and writers such as Marion Nestle, Eric Schlosser, and Ruth Reichl. Among them is Raj Patel who has witnessed and commented on the powerful results of the program,

> "The Edible Schoolyard Project takes literature, politics, biology, history, and science out the classroom and lets young people cultivate their disciplines in a garden, stew them in a kitchen, and discuss them over a table, together and with love. The result: some of the most joyful, committed, and thoughtful young people I've ever met."[30]

Similarly, Michael Pollan has recognized the importance of The Edible Schoolyard Project in addressing some of the challenges of today,

> "To spend time in an Edible Schoolyard is to realize how much more is going on here than teaching kids how to garden or cook. Kids begin to learn about food in all its dimensions – as an edible medium of culture, science, ecology, and even social justice. The Edible Schoolyard is an eloquent and practical answer to some of the most pressing questions facing us as a society."[31]

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[27] Ibid.
[28] "Edible Schoolyard Berkeley," The Edible Schoolyard Project, accessed February 22, 2019, https://edibleschoolyard.org/berkeley.
[29] Cornforth, "The Edible Schoolyard."
[30] "Edible Schoolyard Berkeley."
[31] "Our Story," The Edible Schoolyard Project, accessed February 22, 2019, https://edibleschoolyard.org/about.

In the 24 years since the program was founded, The Edible Schoolyard Project has expanded in order to positively influence children far beyond Berkeley. The Edible Schoolyard Network connects over 5,500 programs from across all 50 states and 75 countries around the world. Additionally, the organization offers training programs that more than 900 teachers, administrators, and community members have participated in in order to gain the tools and skills necessary for developing edible education programs at their own schools.[32] Finally, the project offers an abundance of free online resources that include lesson plans, program development tools, and information on school food reform.

Grow to Learn NYC

In 2010, Grow to Learn NYC, a citywide school garden initiative, was founded in 2010 as a public-private partnership between GrowNYC,[33] the Mayor's Fund to Advance New York City, and several government agency partners. The program's mission is to "inspire, promote and facilitate the creation of sustainable gardens in public schools throughout New York City."[34] The organization carries out this mission by helping schools develop long-lasting and impactful gardens that are both responsive to each community's vision and needs, and transformative for student learning.[35]

Although Grow to Learn NYC does not directly create school gardens, they provide funding in the form of mini-grants and free garden materials like seeds, lumber, soil, and compost. They also have skills-building workshops and a network of resources for those leading

[32] Ibid.
[33] GrowNYC is a nonprofit organization that was founded in 1970 as a part of the first Earth Day. Today, it is the largest environmental organization in New York City that is on a mission to improve the city's quality of life through environmental programs that support 3 million participants every year.
[34] "Grow to Learn NYC: The Citywide School Gardens Initiative," accessed February 23, 2019, https://www.grownyc.org/grow-to-learn.
[35] "Grow to Learn NYC," Grow To Learn, accessed February 23, 2019, http://www.growtolearn.org/.

the school gardens. In doing so, they have been instrumental in creating active spaces that connect students ranging from grades K-12 to the natural world across New York City.

In collaboration with the Laurie M. Tisch Center for Food Education & Policy, Grow to Learn NYC has also developed the Seed to Plate curriculum, which takes an interdisciplinary approach towards educating fifth and sixth graders about food systems and nutrition. It can be incorporated into science, social studies, health, or English classes in order to promote healthier food choices and environmental stewardship.[36]

Garden School Foundation

The Garden School Foundation is a nonprofit organization in Los Angeles, California that was founded in 2005 to support the efforts of a coalition of educators and community members who recognized the opportunity to transform a 1.5-acre blacktop lot at 24th Street Elementary School into a garden classroom.[37] With the spirit of their motto, "beet the asphalt," the organization created a diverse green space that includes an orchard with 60 fruit trees, 35 productive vegetable beds, native plantings, and a compost operation.[38] Students in all grades spend time in the garden each week as it is incorporated into a variety of their classes. They are also exposed to nutrition education through cooking demonstrations led by local chefs.[39]

The school's surrounding neighborhood, West Adams, is a food desert and many of the children come from low-income backgrounds. The garden not only provides these children with interactive learning opportunities, but it gives them and their neighbors a source of fresh

[36] The Seed to Plate curriculum has been taught in 17 schools and in over 85 classrooms and has educated over 2000 NYC students since 2012.
[37] About Us | Garden School Foundation. (n.d.). Retrieved February 23, 2019, from http://gardenschoolfoundation.org/about-us/
[38] Hkam, H. (2017). *Garden School Foundation: Connecting Kids With Nature*.
[39] Velez, A. (2010, January 19). School Gardens Across the Nation, and a Resource List for Starting Your Own.

produce. It also helps cultivate community by bringing together families and volunteers each month for Community Garden Days that are attended by upwards of 150 people.[40]

Today, the Garden School Foundation has expanded beyond its flagship location and now serves seven Title 1 schools throughout Los Angeles in order to strengthen connections between food justice, environmental awareness, and community health.[41] They have developed a curriculum called Seed to Table that includes 120 lessons aligned to the Common Core and State Standards. The lessons taught over the course of six years of elementary school bring academic concepts to life by engaging children in real-world experiences. Through the program, children learn how to grow, harvest, and cook their own produce, while gaining an understanding of how their actions impact both their communities and the environment at large.[42]

What Makes Them Successful

These three organizations differ in the ways that they contribute to garden-based education in schools and communities. Grow to Learn NYC simply provides the resources necessary for implementing garden-based learning programs, while the Garden School Foundation directly creates and manages them. The Edible Schoolyard does a combination of the two by maintaining a garden in Berkeley, while also supporting garden programs across the world through resources. Though the three have different ways of addressing them, they share a number of aligned goals.

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[40] "Our Schools | Garden School Foundation," accessed February 23, 2019, http://gardenschoolfoundation.org/our-schools/.
[41] "About Us | Garden School Foundation," Garden School Foundation, accessed February 23, 2019, http://gardenschoolfoundation.org/about-us/.
[42] "Our Programs | Garden School Foundation," Garden School Foundation, accessed February 23, 2019, http://gardenschoolfoundation.org/our-programs/.

The missions of all three emphasize leveraging school gardens to educate students about nutrition and the environment in order to promote healthier food choices and environmental stewardship. Each of the organizations also works to integrate the gardens into other school subjects, so that students may have more interactive learning opportunities. Additionally, they involve various members of their communities to expand their reach and create more vibrant neighborhoods.

Along with these shared goals, The Edible Schoolyard, Grow to Learn NYC, and the Garden School Foundation, have other commonalities. Respondents of a survey carried out to identify barriers to integration and sustainability of school gardens found five shared themes. Successful programs create community, are inviting spaces, are resourced and supported, are thriving, and are used.[43] Furthermore, three subthemes emerged with respect to the theme "is used." They found that successful gardens are incorporated within the school curricula, are used to create a positive student experience, and are venues to teach about environmental health and sustainability. If garden programs work towards developing these features as The Edible Schoolyard, Grow to Learn NYC, and the Garden School Foundation have, they may reach their potential to significantly benefit the students that participate in them.

An Analysis of the Benefits

Many researchers have studied the impacts of school gardens and the various student outcomes that they achieve. Although there is a good deal of research on the benefits of these programs, an understanding of the long-term effects of such is limited because of the high costs and time associated with longitudinal studies. For the most part, the research undertaken on

[43] Kate G. Burt et al., "School Gardens in the United States: Current Barriers to Integration and Sustainability," *American Journal of Public Health*; Washington 108, no. 11 (November 2018): 1543–49, http://dx.doi.org.libproxy.lib.unc.edu/10.2105/AJPH.2018.304674.

school gardens is in the form of short-term intervention studies or evaluation studies.[44] Still, there is a multitude of evidence that points to positive results of engagement with school gardens. Garden-based learning has the potential to not only be an effective tool in promoting healthier diets and environmental awareness, but it also provides developmental benefits related to physical, mental, and social health. Additionally, there is significant evidence that points to advantageous academic outcomes, which may serve as a particularly important rallying point for building support for these programs.

Nutrition Outcomes

One of the key modern goals of garden-based learning programs is to provide a form of nutrition education that ultimately leads to improved eating habits. Multiple studies have been conducted in order to test their effectiveness at doing so. One studied the effect of garden-based programs at increasing fruit and vegetable consumption among sixth-graders by using a nonequivalent control group design. Three different elementary schools participated in the study. Two of them served as control groups and one served as the experimental group, which took part in the *Nutrition in the Garden* curriculum.[45] Each student partaking in the study completed a series of food-recall workbooks before and after the treatment was administered. The results indicated that the treatment had a significant effect on the fruit and vegetable consumption of students. Fruit consumption increased 1.13 servings per day and vegetable consumption

[44] Pernille Dyg and Karen Wistoft, "Wellbeing in School Gardens – the Case of the Gardens for Bellies Food and Environmental Education Program," *Environmental Education Research* 24, no. 8 (May 10, 2017): 1171–91.

[45] The *Nutrition in the Garden* curriculum, created by Sarah Lineberger and Jane Zajicek, consists of lessons and activities that integrate nutrition education into a horticulture program. The lessons teach students about plant growth, the food pyramid, food safety, and more.

increased 1.44 servings per day among students in the experimental group. Likewise, intake of vitamin A, vitamin C, and fiber also increased.[46]

Another study conducted among fourth-grade students yielded similar results related to vegetable knowledge and preference. One elementary school served as a control group while two schools were experimental groups that participated in nine nutrition lessons on topics like plants, nutrients, consumerism, and the Food Guide Pyramid. A garden component was also incorporated into each lesson. The effects were evaluated through pre- and post-test nutrition knowledge questionnaires and vegetable preference surveys. The students who were a part of the experimental groups scored significantly higher on the nutrition knowledge questionnaire after participating in the nutrition lessons. Additionally, the experimental students developed improved preferences for several vegetables, including those that they were not directly exposed to in the garden. The study also made efforts to identify long-term effects by conducting a 6-month follow-up survey. For the most part, the improvements in nutrition knowledge and vegetable preferences were maintained even after six months had passed.[47]

School gardens also increase students' willingness to try new foods. An evaluation of in-school nutrition education interventions among kindergarten students found that once garden activities were implemented in the existing language arts and science curriculum, students were 69% more willing to taste new fruits and vegetables. Additionally, their ability to correctly

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[46]Jessica D. McAleese and Linda L. Rankin, "Garden-Based Nutrition Education Affects Fruit and Vegetable Consumption in Sixth-Grade Adolescents," *Journal of the American Dietetic Association* 107, no. 4 (April 2007): 662–65, https://doi.org/10.1016/j.jada.2007.01.015.

[47] Jennifer L. Morris and Sheri Zidenberg-Cherr, "Garden-Enhanced Nutrition Curriculum Improves Fourth-Grade School Children's Knowledge of Nutrition and Preferences for Some Vegetables," *Journal of the Academy of Nutrition and Dietetics* 102, no. 1 (January 1, 2002): 91–93, https://doi.org/10.1016/S0002-8223(02)90027-1.

identify fruits increased from 52% to 94% and their ability to name different types of vegetables increased from 43% to 86%.[48]

The results of these various studies indicate that school gardens are effective tools for promoting an increased awareness of, willingness to try, and consumption of fruits and vegetables. If implemented, garden-based learning has the potential to generate positive outcomes as optimal fruit and vegetable intake is associated with good health and reduced risk of diseases such as obesity and cardiovascular disease.[49] The National Health and Nutrition Survey indicated that only 9% of children between the ages of 6 and 11 eat the recommended five servings of fruit and vegetables each day.[50] Garden-based nutrition education should be implemented in order to address this.

Environmental Awareness

The body of research on the effects of garden programs on the improvement of environmental attitudes is less wide. However, a few researchers have determined through experimental studies and surveys that garden-based learning does generate more positive views of the environment.[51]

A research study was carried out to determine the impact that the school garden program, Project GREEN, had on the participants' attitudes towards environmental issues. The results indicated that those students who attended the schools where the Project GREEN program was

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[48] Katherine L. Cason, "Children Are 'Growing Healthy' in South Carolina," *Journal of Nutrition Education* 31, no. 4 (July 1, 1999): 235–36, https://doi.org/10.1016/S0022-3182(99)70446-2.
[49] Ramona Robinson-O'Brien, Mary Story, and Stephanie Heim, "Impact of Garden-Based Youth Nutrition Intervention Programs: A Review," *Journal of the American Dietetic Association* 109, no. 2 (February 2009): 273–80, https://doi.org/10.1016/j.jada.2008.10.051.
[50] Cason, "Children Are 'Growing Healthy' in South Carolina."
[51] Bridget Ann Cross, "The Impact of a School Garden and Environmental Education on the Environmental Awareness of Fifth Graders" (M.A., Southeastern Louisiana University, 2013), http://search.proquest.com/docview/1354473402/abstract/BB239503E30D42E0PQ/1.

integrated into the curriculum developed more positive outlooks on varying environmental issues.[52]

Another group of researchers determined that school gardening has long-term impacts on environmental attitudes. The study involved a nationwide phone survey of attitudes towards trees and gardening of those living in metropolitan areas like Los Angeles, Chicago, and Atlanta. The aim was to measure how children's active and passive interactions with plants influence their attitudes as adults. They analyzed eleven various childhood experiences such as playing in local parks, spending time in the woods, and actively caring for plants. Of these, participating in active gardening during childhood had the most significant effect on environmental attitudes and engagement. These attitudes were measured by the responses to three survey items, "Trees in cities help people feel calmer," "Do trees have a particular personal, symbolic, or spiritual meaning to you?" and "During the past year, have you participated in a classroom or program about gardening?" These three prompts indicated how one values trees both socially and intrinsically and whether they take environmental actions in adulthood. Those who actively engaged with gardening as a child were the most likely to recognize the value of trees and participate in gardening activities as adults.[53]

Today, children are rapidly losing direct contact with nature in their daily lives. Instead, school-aged children in the United States are spending around seven hours per day in front of an

[52] Tina M. Waliczek and Jayne M. Zajicek, "School Gardening: Improving Environmental Attitudes of Children through Hands-on Learning," *Journal of Environmental Horticulture* 17, no. 4 (January 1999), https://www.researchgate.net/publication/285477581_School_gardening_Improving_environmental_attitudes_of_children_through_hands-on_learning.

[53] Virginia Lohr and Caroline Pearson-Mims, "Children's Active and Passive Interactions with Plants Influence Their Attitudes and Actions toward Trees and Gardening as Adults," *HortTechnology* 15, no. 3 (July 2005), https://doi.org/10.21273/HORTTECH.15.3.0472.

electronic screen.[54] Time spent exploring the outdoor environment has been replaced by time spent in front of cell phones and tablets. Richard Louv entitled the resulting condition, "nature-deficit disorder" to describe the human costs associated with alienation from nature.[55] One of these is that children are becoming less and less aware of what is going on in the natural environment, which weakens ecological literacy and stewardship of the natural world. Teaching children about environmental justice is imperative for the development of a sustainable future. Garden-enhanced learning programs not only provide an opportunity for students to learn about the environment, but they give them the opportunity to interact with it. By engaging with gardening, children can witness firsthand the ways in which they impact the environment and how it impacts them.

Academic Outcomes

In the United States, the public school system generally emphasizes student achievement as measured by standardized test scores over the holistic growth of a student. Many believe that every available minute of class time should be focused on meeting the national academic standards. For this reason, it is important that there is a justification for the academic value of school gardens in order to generate widespread support. Fortunately, there is evidence that backs the claim that garden-based learning leads to improved academic achievement. This is particularly evident in the field of science.

The ever-changing nature of a garden is attractive to children and helps stimulate their attention. Engaging with them inspires cognitive development by provoking the need in children

[54] Hales, "Prevalence of Obesity Among Adults and Youth: United States, 2015–2016."
[55] Richard Louv, *Last Child in the Woods: Saving Our Children From Nature-Deficit Disorder* (Algonquin Books, 2008).

to make sense of what they have experienced.[56] According to social ecologist, Stephen Kellert, experiencing nature "reinforces the child's capacities for empirical observation, analytical examination, and evidentiary demonstration."[57] The development of these higher-order cognitive skills is very applicable to the fields of science and mathematics.

A randomized control trial of low-income elementary schools found that garden intervention encouraged improvements in science achievement. The study also determined that the strength of garden intervention matters. Those students in the experimental groups who had been exposed to more garden lessons scored higher on the science knowledge questionnaire than the students who had participated in fewer lessons.[58]

School gardens promote better academic outcomes by giving students the opportunity to have an engaging learning experience that generates excitement about the material being taught. Many education experts have found that during their preschool and elementary years, children learn best through "active, engaged, meaningful experiences."[59] Garden-based education is able to provide these types of learning opportunities. Gardens serve as living laboratories in which students can see and apply what they are learning in a real-world situation. Rather than being mere consumers of the curriculum, students become creators in it.[60] As a result, the content learned, and skills developed in a garden last longer than those learned in a traditional classroom setting.

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[56] Dorothy Blair, "The Child in the Garden: An Evaluative Review of the Benefits of School Gardening," *The Journal of Environmental Education*; Madison 40, no. 2 (Winter 2009): 15–38.
[57] Ibid., p. 19.
[58] Nancy Wells et al., "The Effects of School Gardens on Children's Science Knowledge: A Randomized Controlled Trial of Low-Income Elementary Schools," *International Journal of Science Education* 37, no. 17 (November 30, 2015): 2858–78.
[59] Jaime Grimm-Rice, "A Master's Research Project Presented to The Faculty of the College of Education Ohio University" (Ohio University, 2011).
[60] Blair, "The Child in the Garden."

Other Benefits

In addition to improved academic, nutrition, and environmental outcomes, garden-based learning programs also have many other psychosocial, albeit less quantifiable, benefits that promote the overall well-being of the individual students who participate in them.[61] Gardening is a form of exercise which has positive effects on physical health and mental health. Examples of these improvements specific to gardening are reductions in depression and anxiety and an increase in cognitive function and life satisfaction. Gardening can also provide "an instantaneous beneficial influence on health," meaning that these health improvements happen immediately after participating.[62] Thus, when students are given the opportunity to garden in schools, they are exposed to these benefits while they are growing academically.

Lessons in business and entrepreneurship may be integrated into school gardens, which can support the development of important life skills. Through engagement with school gardens, students are able to directly participate in the production of marketable and highly valued goods. Some garden-based learning programs have taken advantage of this by encouraging students to sell the locally-raised produce or value-added goods made with the fruits and vegetables grown in the gardens. For example, the nonprofit organizations Food Growing Schools London and Sustain: the alliance for better food and farming put on a school marketplace at London's City Hall every year. The event brings together students from schools across the city and gives them business experience by providing them with a platform for selling their products to paying

[61] Dyg and Wistoft, "Wellbeing in School Gardens – the Case of the Gardens for Bellies Food and Environmental Education Program."
[62] Masashi Soga, Kevin J. Gaston, and Yuichi Yamaura, "Gardening Is Beneficial for Health: A Meta-Analysis," *Preventive Medicine Reports* 5 (November 14, 2016): 92–99, https://doi.org/10.1016/j.pmedr.2016.11.007.

customers.[63] This allows students to gain real-world practice in leadership, marketing, and customer service. In addition to the business skills acquired through the process of taking produce to market, school gardens may raise money that can be used to support and expand programming.

Beyond the impacts on the individuals participating in the programs, educational gardens have advantages that extend to the whole community. School gardens can improve interpersonal relations and generate a sense of community among students. Teachers also benefit from them. One study indicated that teachers working at schools with gardens had higher workplace morale and increased satisfaction with their jobs.[64] Additionally, if taken advantage of, school gardens can be leveraged to support the entire community. Programs like the Garden School Foundation that open the garden for work days allow the larger community to experience the benefits of gardening and create social ties by bringing people together to cultivate the land. The experience can have a domino effect as the landscape architect, Lauren Mandel describes, "Community members interact with one another, experience where their food comes from, celebrate nourishment, and ultimately are inspired to teach friends and family about their experience."[65] This public participation can, in effect, further perpetuate the gains of the individual student as community involvement has been directly linked to improved student achievement, higher attendance rates, better social skills, and higher rates of postsecondary education.[66]

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[63] "Young Growers Create Schools Marketplace Success," Sustain: the alliance for better food and farming, October 18, 2017, https://www.sustainweb.org/news/oct17_school_market/.
[64] Sonja Skelly and Jennifer Bradley, "The Importance of School Gardens as Perceived by Florida Elementary School Teachers," *HortTechnology* 10, no. 1 (January 2000), https://doi.org/DOI: 10.21273/HORTTECH.10.1.229.
[65] Lauren Mandel, *Eat Up: The Inside Scoop on Rooftop Agriculture* (Gabriola Island, BC: New Society Publishers, 2013).
[66] Catherine Jordan, Evangelina Orozco, and Amy Averett, "Emerging Issues in School, Family, & Community Connections" (National Center for Family & Community Connections with Schools, 2001).

The Effect on the Urban Youth

The benefits generated by school gardens have the potential to affect urban youth in a unique way because of their specific life experiences. Research has shown that school gardens specifically give children growing up in cities a better understanding of the environment and a sense of belonging to the community that is often missing from the urban experience.[67]

Urban youth differ in that they face higher rates of poverty than their rural and suburban counterparts. According to the 2015 American Community Survey, the poverty rate for rural households was 13.3% whereas the poverty rate for urban households was 16%.[68] Additionally, only 19% of students from urban school districts go on to seek higher education, which is significantly lower than the 70% of their suburban counterparts.[69]

The poverty that urban youth are more likely to experience is directly tied to higher rates of food insecurity and plays a significant role in determining food choices. Children growing up in poor households are more likely to be exposed to cheap, but unhealthy, processed and fast foods. A study conducted by researchers at Tufts University found that between 33 and 50 percent of poor children have deficient intakes of key nutrients. They are 2.5 times more likely to have insufficient intakes of food energy and key vitamins.[70] In addition to lacking proper nutrients, children exposed to these unhealthy foods are likely to develop preferences for them that shape their food choices into adulthood. This is because food preferences are learned

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[67] Anjali Barnick, "The Impact of a School Gardening Program on Nutrition Attitudes, Behaviors and Interests Amongst Fourth Grade Students" (Cleveland State University, 2014).
[68] Alemayehu Bishaw and Kirby Posey, "A Comparison of Rural and Urban America: Household Income and Poverty," The United States Census Bureau, December 8, 2016, https://www.census.gov/newsroom/blogs/random-samplings/2016/12/a_comparison_of_rura.html.
[69] Whitney Wright, "The Disparities between Urban and Suburban American Education Systems: A Comparative Analysis Using Social Closure Theory" (Department of Political Science Howard University, March 31, 2012).
[70] John T. Cook and Katie S. Martin, "Differences in Nutrient Adequacy among Poor and Non-Poor Children" (Center on Hunger, Poverty and Nutrition Policy, Tufts University, 11 Curtis Ave, March 1995).

through one's experience with food and eating.[71] Many children who grow up in urban areas with high poverty rates may never be exposed to the types of fruits and vegetables that are required for proper development. School gardens provide an opportunity for these children to gain exposure to healthier foods and have access to produce that they might not otherwise have.[72]

Improving the diets of children through school gardens may also play a role in helping address the achievement gap that exists between low- and high-income students. This is due to the fact that diet and academic outcomes are inherently connected. Those who consume nutritionally adequate meals are more likely to perform better academically.[73] School gardens may also contribute to closing the achievement gap by improving the quality of education and generating excitement for learning among students.

The additional green space in areas in which it is limited that school gardens provide may also have more profound mental health benefits. In a recent study cited in the *Journal of the American Medical Association,* these benefits were tested by asking city residents to rate their feelings of things like anxiety, hopelessness, worthlessness, and depression before and after green spaces were implemented in their neighborhoods. The study found that green intervention decreased residents' feelings of depression by more than sixty-eight percent.[74] School gardens

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[71] L. L. Birch, "Development of Food Preferences," *Annual Review of Nutrition* 19 (1999): 41–62, https://doi.org/10.1146/annurev.nutr.19.1.41.

[72] There are many school programs that incorporate produce from the gardens into their cafeterias to further students' interaction with the food they grow. However, there are food safety regulations that prevent this from always being feasible. Regardless, children often have the opportunity to take produce from the school gardens home with them.

[73] Burns et al.; Eero A. Haapala et al., "Diet Quality and Academic Achievement: A Prospective Study among Primary School Children," *European Journal of Nutrition* 56, no. 7 (October 2017): 2299–2308, https://doi.org/10.1007/s00394-016-1270-5; Michelle D. Florence, Mark Asbridge, and Paul J. Veugelers, "Diet Quality and Academic Performance," *The Journal of School Health* 78, no. 4 (April 2008): 209–15; quiz 239–41, https://doi.org/10.1111/j.1746-1561.2008.00288.x.

[74] Linda Poon, "The Mental-Health Benefits of Turning Vacant Lots Green," CityLab, July 30, 2018, https://www.citylab.com/environment/2018/07/the-healing-potential-of-turning-vacant-lots-green/566066/.

can promote the mental health of students and if made accessible to the public, can also have beneficial effects of residents of the surrounding community.

The Challenges

While there are many rewarding aspects of garden-based education programs, especially for urban youth, there are also many challenges to implementing and sustaining them in the long-term. A 2018 study that surveyed school gardeners identified the largest barriers to building out these programs as funding, staffing, time, curriculum, and space.[75] Additional challenges outlined by the *Food Growing in Schools Taskforce Report* include the difficulty of synchronizing the curriculum with food growing seasons, health and safety concerns, and lack of support from senior leaders.[76] There are a number of existing resources that help mitigate these challenges such as grant funding from various government and nonprofit entities, well-developed curricula that are available online for educators to access, and organizations like FoodCorps that provide service members to initiate school garden programs.

Though these resources exist, it is important to consider innovative solutions to the challenges that are intensified in cities so that more urban youth may engage with school gardens and reap the many benefits that come with doing so. Because they host millions of people in concentrated areas, urban environments have specific infrastructure and resource demands that significantly impact the environmental landscape and its ability to host a garden. The activities involved in the urbanization process such as the construction of new buildings and migration of people contribute to poor air and water quality, waste-disposal problems, insufficient water

[75] Burt et al., "School Gardens in the United States."
[76] "Food Growing in Schools Taskforce."

availability, and high energy consumption.[77] The concentrated consumption of energy contributes to the creation of heat islands, which alter weather patterns and the overall temperature of cities. The ubiquitous heat-absorbent surfaces like concrete and asphalt perpetuate the problem by keeping cities from radiating heat back into the atmosphere. In comparison to rural areas, urban environments radiate 15 to 30 percent less heat back into the atmosphere.[78] These heat islands trap atmospheric pollutants, which induces a higher prevalence of cloudiness and fog.

The soil is one subject of these environmental issues that is particularly relevant to urban gardens. As with the rest of the city landscape, urban soil has been disturbed and manipulated by human activity. Compaction, caused by urban construction and restoration activity, reduces the ease of root penetration, decreases the movement of water, and reduces the overall water-holding capacity of the soil.[79] The elevated temperatures resulting from the heat island effect increase the internal temperatures of the soil and contribute to the moisture stress on vegetation, which results in less vigorous plant growth.[80] Poor soil health, along with obstacles to root growth caused by underground infrastructure, gives rise to further complications with ground-level urban growing projects.

In addition to the environmental degradation caused by urban demands, limited availability of space is another barrier that is heightened in cities. There is a finite supply of land in cities, which causes it to be extremely expensive, often preventing a school from being able to create learning gardens. Though there is no single catch-all solution to the many impediments to

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[77] "Urbanization Causes and Impacts," National Geographic, accessed March 25, 2019, https://www.nationalgeographic.com/environment/habitats/urban-threats/.
[78] Barbara Boyle Torrey, "Urbanization: An Environmental Force to Be Reckoned With," Population Reference Bureau, April 23, 2004, https://www.prb.org/urbanization-an-environmental-force-to-be-reckoned-with/.
[79] Phillip J. Craul, "Urban Soil: Problems and Promise," Urban Soils, n.d., 23–32.
[80] Ibid.

developing school gardens in cities, rooftops, which have recently become an expanding source of green space in urban landscapes, may begin to address some of them. They not only provide the available space necessary for the expansion of urban school gardens but also serve as a remedy for some of the environmental challenges that exist in cities.

Chapter 2: Taking Garden-Based Learning to New Heights

In order to expose more children growing up in cities to the benefits of garden-based learning, the available space on rooftops may be leveraged as sites for school gardens. Educating students through rooftop gardens does not require a reinvention of the wheel. As discussed in the previous chapter, garden-based education programs have been well-established and widespread. Rooftop growing has also become more developed over the past few decades. The advancement has led to roof gardens and farms that are nearly indistinguishable from those planted directly in the earth.

With the limited available land in cities, it is worth considering how these two existing practices may be combined in order to expose more urban youth to the advantages of garden-based learning programs. Projects such as the Fifth Street Farm, the Rothenberg School Rooftop Garden, Eastdale Collegiate's Rooftop Market Garden, the Greenhouse Project at the Manhattan School for Children, and City Growers exemplify the types of opportunities that exist at the intersection of garden-based learning and rooftop growing.

Though creating school gardens on roofs requires overcoming financial and infrastructure barriers, doing so yields benefits for individual students, their communities, and the urban environment. In addition to providing space for outdoor learning, roof gardens may uniquely combat some environmental issues, such as the urban heat island effect and combined sewage overflow, which plague cities around the world.

Overview of Rooftop Growing

Brief History of Rooftop Growing

Growing plants on the tops of buildings is no new phenomenon. Rooftop growing spaces date back to as early as the sixth century B.C. with the creation of the Hanging Gardens of Babylon. King Nebuchadnezzar had the gardens built for his Median wife, who missed the green mountains of her native land. After the completion of these gardens, which would later become one of the Seven Wonders of the Ancient World, other nobles began erecting terraced gardens. About a century later in Rome, as wealthy families developed large decorative gardens throughout the city, they took growing space away from lower class citizens. In order to maintain their food supply, working-class city-dwellers ended up replanting their gardens on their roofs.[81]

Rooftop gardens came to have a significant role later in history during The Renaissance. With the cultural and artistic advances of the time came the development of the oldest and best-preserved roof garden from the modern era. In Pienza, a town in Tuscany, Italy, Pope Pius, an early humanist and patron of learning and the arts, had an ecclesiastical center built with a formal garden on top adorned by a series of three overlapping loggias.[82] Because it is still standing today, the garden exemplifies the longevity of these above ground growing operations. Ornamental rooftop gardens continued to spread throughout Europe between 1600 and 1875. They were regarded as a great sign of wealth and were often reserved for the nobility. Among those who experienced the luxury of a roof garden were cardinal Johann van Lamburg of Germany, Catherine II of Russia, and King Ludwig II of Bavaria.[83]

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[81] Richardson Wright, *The Story of Gardening: From the Hanging Gardens of Babylon to the Hanging Gardens of New York* (New York: Dover Publications, 1934).
[82] Theodore H. Osmundson, *Roof Gardens: History, Design, and Construction* (New York: W. W. Norton & Company, 1999).
[83] Ibid.

Though these early examples of rooftop gardens mainly hosted bushes and flowers, which served purely decorative purposes, the ancient origins of rooftop growing are indicative of the longstanding attraction humans have towards the practice. Rather than a fad that comes and goes, rooftop gardening is an enduring method of urban agriculture that has continued to advance over the years. Recent trends in roof gardens have moved away from aestheticism towards pragmatism. More common today are practical developments like green roofs for storm management, gardens on tops of restaurants for sourcing menu ingredients, and hydroponic farms for the small-scale production of vegetables and herbs.

The State of Rooftop Growing Today

The popularity of green roofs has increased drastically as technologies for implementing them have been developed and their benefits have been realized. Although they include rooftop gardens and farms, green roofs are more broadly defined as "an extension of the existing roof which involves, at a minimum, high-quality waterproofing, root repellent system, drainage system, filter cloth, a lightweight growing medium, and plants."[84] Green Roofs for Healthy Cities, an industry association that advocates for the implementation of green infrastructure, reported that the North American green roof industry experienced an estimated 10.3 percent growth in 2016 over 2015. This growth involved the installation of 4.1 million square feet of green roofing, which is estimated to yield benefits of 46.8 million gallons of stormwater retained per year, 141.5 tons of carbon sequestered every two years, and 6.03 million kilowatt hours of

[84] "About Green Roofs," Green Roofs for Healthy Cities, accessed March 25, 2019, https://greenroofs.org/about-green-roofs.

energy saved per year.[85] This growth conveys the strength of the current movement towards sustainable alternatives to traditional black tar and asphalt roofs.

Along with the spread of green roofs, the development of rooftop gardens and farms, which more specifically, focus on production, has taken off. Although the difference between the two has not been explicitly defined, stakeholders typically agree that gardening is generally the method used to produce goods for self-consumption, charity or gifting. Farming, on the other hand, is the production of the same agricultural goods, but in exchange for money.[86] Though more commonly tied to the former, garden-based education may also be incorporated into profitable rooftop farms as well. The labels of "garden" and "farm" are often used interchangeably, especially in the names of growing projects.[87]

Today, rooftop gardens and farms can be found in almost every city across the country.[88] Their size and structures vary as they range from small-scale growing projects that utilize temporary structures to large-scale operations that use soil-based methods or technology-focused systems. These categories are often referred to as *informal, formal,* and *technological* rooftop agriculture.[89] Each installation configuration has its own unique impact on cities and faces distinct challenges.

Rooftop growing operations that utilize containers fall into the category of informal rooftop agriculture, which makes use of temporary infrastructure to raise produce. Examples of these span from small gardens that use containers such as Graze the Roof in San Francisco to

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[85] Blaine Stand and Steven W. Peck, "2016 Annual Green Roof Industry Survey Executive Summary" (Green Roofs for Healthy Cities, July 2017).
[86] Mandel, *Eat Up: The Inside Scoop on Rooftop Agriculture*.
[87] For example, Fifth Street Farm, a school rooftop-growing project is more aligned with the general definition of a garden than with that of a farm.
[88] Amy Azzarito, "From Babylon to Brooklyn: The History of Rooftop Gardens," Food52, March 2, 2015, https://food52.com/blog/12407-from-babylon-to-brooklyn-the-history-of-rooftop-gardens.
[89] Francesco Orsini et al., eds., *Rooftop Urban Agriculture* (Cham, Switzerland: Springer International Publishing, 2017).

farms like Higher Ground in Boston, which operates on a total of about 4,500 square feet of productive growing space and works completely out of milk crates.[90] The set-up costs of growing projects that make use of temporary structures are significantly lower than those of soil-based and technologically advanced systems. Additionally, the installation requires significantly less time. With the help of fifteen employees and volunteers, Higher Ground was able to set up their second location at the Boston Medical Center in only four hours.[91] The temporary nature of informal rooftop agriculture also yields less intense permitting, which makes the entire course of development less complicated.[92]

Soil-based rooftop growing operations are categorized as formal rooftop agriculture and involve a more intense and permanent installation process. For example, building the Brooklyn Grange, the world's largest soil-based rooftop farm, involved a lengthy search for a suitable rooftop structure, lease negotiations, and a strenuous installation process that included covering the roof with four layers of support material before adding soil and an irrigation system.[93] Though the Brooklyn Grange focuses on generating 50,000 pounds of organically cultivated produce per year, the business maintains a triple-bottom-line philosophy, which recognizes the importance of people and the planet in addition to profit. In accordance with this, they have contributed to the community through educational programs, fruit and vegetable donation, and by serving as a community gathering space. Additionally, they support the environment by mitigating combined sewage overflow that is especially problematic in New York City,

[90] Chris Blanchard, John Stoddard and Lindsay Allen of Higher Ground Farm on the Journey from Idealism to Practicality on a Rooftop Farm, Farmer to Farmer Podcast, n.d.
[91] Ibid.
[92] "Higher Ground Rooftop Farm," Farmland Access, accessed March 25, 2019, https://farmlandaccess.org/higher-ground/.
[93] Danielle Knott, "Brooklyn Grange Tour" (October 20, 2018).

managing an estimated two million gallons of stormwater per year, and reducing the urban heat island effect.[94]

Technological rooftop agriculture incorporates technology-based systems like indoor environmental control, aquaponics, and hydroponics in order to produce high yields of fruits and vegetables.[95] Gotham Greens, a pioneer in developing technologically advanced urban agriculture practices, manages a total of four acres of rooftop greenhouse space. The key benefit of this form of rooftop growing is the opportunity it creates to grow large quantities of fresh, local produce year-round. On only one-third of an acre, they are able to produce 100,000 pounds of produce per year.[96] The major downside to this method is the extremely high cost of implementation and management. In order to become as successful as they are today, Gotham Greens required the support of venture capital funding in the amount of $30 million. Unlike informal and formal rooftop agriculture, technological systems are generally not engaged with the community beyond serving as a source of local produce. Instead of contributing to the community through direct interaction, they aim to make an impact through their sustainable practices and products.

Educating the Urban Youth through Rooftop Gardening

Existing Rooftop Garden Education Programs

Though not yet widely spread, there are existing programs that utilize rooftop growing space to educate the urban youth. These projects have primarily manifested in two different

[94] "Brooklyn Grange Factsheet," n.d., https://static1.squarespace.com/static/569fd2b522482eeee4fcfa53/t/5a5fe40f71c10b8fa3bb553d/1516233743700/Brooklyn+Grange+-+fact+sheet+EPK.pdf.
[95] Orsini et al., *Rooftop Urban Agriculture*.
[96] "Gotham Greens," accessed March 25, 2019, http://www.gothamgreens.com/.

ways. Developments like Fifth Street Farm, Rothenberg School Rooftop Garden, Eastdale Collegiate's Rooftop Market Garden, and the Greenhouse Project at P.S. 333 Manhattan School for Children have been created with the primary purpose of educating students through garden-based learning. Other programs, like City Growers, have grown out of existing rooftop farming operations. As is the case with educational gardens in general, rooftop learning gardens have been developed by educators and volunteers tied to school systems, by external nonprofit organizations, and in most examples, a combination of both. All of them, with the exception of the Greenhouse Project, utilize informal rooftop agriculture methods.

Fifth Street Rooftop Farm, situated in the East Village, is a collaborative educational project that was created in 2012 to provide inner-city children with a greater awareness of the natural world.[97] The garden spans 2,400 square feet and is located on top of a building that houses three New York City public schools, the Earth School, Public School 64, and Tompkins Square Middle School. Michael Arad, the architect who designed the World Trade Center Memorial, was a key driving force behind the garden. While his son was a student at the Earth School, he chaperoned an apple-picking trip and heard one student proclaim, "What? Apples grow on trees?"[98] The conversation prompted a realization of the extent to which children are disconnected from nature. Following the trip, Arad, along with other parents and teachers, honed the idea for a rooftop farm that would provide children with "an immediate, visceral connection to nature."[99]

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[97] "Fifth Street Farm: A NYC Public School Green Roof Project," accessed March 25, 2019, http://www.5thstreetfarm.org/.
[98] Lisa W. Foderaro, "Schools Add In-House Farms as Teaching Tools in New York City," *The New York Times*, accessed March 25, 2019, https://www.nytimes.com/2012/11/24/nyregion/schools-add-in-house-farms-as-teaching-tools-in-new-york-city.html.
[99] Ibid.

After four years of garnering support, funding, and the necessary city approvals, Fifth Street Farm was built. Arad came up with a raised work bed design that accommodated the building's load-bearing ability along with financial restraints.[100] The garden utilizes informal rooftop agriculture methods with "off the shelf" components, like fiberglass planters and galvanized fencing. Because the design can be easily replicated in other locations, Arad hopes that Fifth Street Farm will become a model for the rest of the city.[101]

The total cost of the project amounted to close to $1 million and was funded primarily by the offices of Scott M. Stringer, the former Manhattan borough president, City Councilwoman Rosie Mendez, and State Senator Daniel Squadron.[102] Fifth Street Farm also created a financial arm that operates as a 501(c)(3) nonprofit organization to oversee fundraising efforts, operations, and maintenance. Today, the rooftop garden acts as a living classroom for students to learn about sustainable agriculture and nutrition. Teachers have incorporated the space into science, math, and humanities lessons.

Similarly, Rothenberg Rooftop School Garden in Cincinnati, Ohio was created with the primary purpose of connecting inner-city children to the natural environment. It also makes use of informal rooftop agriculture techniques by relying on twenty-five garden beds. The garden's inception was part of urban activist, Edwin Coleman's plan for reclaiming and "greening" the school which was at risk of being demolished by revitalization efforts. He worked with the Over-the-Rhine Foundation to gain approval from Cincinnati Public Schools, which ultimately saved

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[100] "Fifth Street Farm: A NYC Public School Green Roof Project."
[101] Foderaro, "Schools Add In-House Farms as Teaching Tools in New York City."
[102] Sarah Darville, "With Rooftop Garden Designed By 'Starchitect,' Earth School Branches Out," The Local East Village, June 20, 2012, http://localeastvillage.com/2012/06/20/green-roof-comes-to-local-school-thanks-to-high-profile-architect/.

the school from bulldozers and led to the realization of his vision with the opening of the rooftop garden in 2014.[103]

The principal long-term goal of the program is to leverage hands-on gardening as an integrator for discipline-specific learning in order to close the achievement gap for inner-city participants.[104] In addition to promoting positive educational outcomes, they hope to create a culture of care and teach students to become active and engaged members of their community. They estimate that over 16,500 children will be served over the thirty-year projected lifespan of the garden.[105]

Another example of a thriving educational rooftop farm rests on top of Eastdale Collegiate in Toronto, Ontario. It is the product of a successful community partnership between the school and the nonprofit organization FoodShare Toronto, which aims to deliver healthy food and food education throughout the city.[106] David Servos, a science teacher at the school, recognized the roof's potential as a space for an urban agriculture project. At the time, he was primarily interested in utilizing the roof for beekeeping education and reached out to FoodShare in search of the resources for actualizing his vision. After his persistent phone calls, FoodShare decided to invest in a project at the school. Though the Toronto District School Board did not approve the original idea for educational beehives due to safety concerns, they recognized the benefits that a school garden could bring to the space.[107]

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[103] "Rothenberg Preparatory Academy Rooftop Garden" (Over the Rhine Foundation, n.d.), http://www.otrfoundation.org/Docs/Background%20Information%20-%20Rothenberg%20Rooftop%20Garden.pdf.
[104] Ibid.
[105] "Our Vision," Rothenberg School Rooftop Garden, accessed March 25, 2019, http://www.rothenbergrooftopgarden.com/our-vision/.
[106] "About | FoodShare," FoodShare, accessed March 25, 2019, https://foodshare.net/about/.
[107] Katie German, "Urban Agriculture in Schools: Eastdale's Rooftop Market Garden," (Webinar, n.d.), https://www.evergreen.ca/tools-publications/urban-agriculture-in-schools-eastdales-rooftop-market-garden/.

Through the partnership with FoodShare, Eastdale Collegiate was able to transform 16,000 square feet of the asphalt roof into productive growing space consisting of 450 mobile garden beds and 300 bucket planters.[108] It has become the largest food-producing roof in Toronto.[109] In addition to serving as a site for students to learn about food systems, the garden serves as a science laboratory and a classroom for other subjects like geology and entrepreneurship. The produce raised in the garden supplies the school's cafeteria and cooking program.[110] It is also sold at farmers' markets and to local restaurants, which generates over $18,000 in sales over the course of a year.[111]

Although open-air, container-based systems are the common form of school rooftop gardens, there are other forms of rooftop agriculture that may be used to educate students. With the support of New York Sun Works, the non-profit organization that builds innovative science labs in urban schools, Public School 333 in Manhattan's West Village has made use of technological rooftop agriculture methods by installing a rooftop greenhouse for year-round hydroponic and aquaponic growing.[112] Sidsel Robards and Manuela Zomora, parents and educators at the school, came up with the initial idea for the project, which they hoped would give their students solid perspectives of the environmental concerns that come from living in a city.[113]

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[108] Ibid.
[109] Louise Brown, "Eastdale Collegiate Opens Its Roof to Urban Agriculture," *The Star*, December 25, 2013, https://www.thestar.com/yourtoronto/education/2013/12/25/eastdale_collegiate_opens_its_roof_to_urban_agriculture.html.
[110] German, "Urban Agriculture in Schools: Eastdale's Rooftop Market Garden."
[111] Ibid.
[112] "Project Overview | NY Sun Works," New York Sun Works, accessed March 25, 2019, https://nysunworks.org/the-greenhouse-project/project-overview/.
[113] "NY Greenhouse Classroom," *Growing A Greener World*, July 8, 2013, https://www.growingagreenerworld.com/episode-401-rooftop-greenhouse-classroom/.

The project facilitates hands-on learning through rainwater catchment, wind energy, aquaponics, worm composting, solar panels and a weather station that allows students to monitor conditions. In addition to significantly enhancing the school's science curriculum, the greenhouse enriches art and social studies by giving students the opportunity to make the connection between nature and culture.

While Fifth Street Farm, Rothenberg Rooftop Garden, the Eastdale Collegiate Rooftop Market Garden, and the Greenhouse Project at Public School 333 exemplify rooftop garden-learning programs that are fully integrated into school curricula, there are also education programs that have been established as part of existing rooftop farms. City Growers, a program based at the Brooklyn Grange is one example.

In addition to spearheading the development of a model for profitable rooftop farms, Brooklyn Grange recognized the rare opportunity that an urban farm provides to connect children raised in the city to food growing practices.[114] They realized that their rooftop farms could serve as engaging learning laboratories. In 2011, they created City Growers, a separately funded 501(c)(3) non-profit organization that brings K-12 students to the farm for educational field trips, after-school programs, and summer camps. In total, they have brought more than 40,000 children up to their roof. They also provide professional development workshops that teach educators how to integrate school gardens into their curriculum in order to enhance classroom learning. These programs have all contributed to the actualization of their mission "to engage with the next generation of urban dwellers" in order to empower them to become advocates for a greener future.[115]

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[114] Knott, "Brooklyn Grange Tour."
[115] "City Growers," accessed March 25, 2019, https://citygrowers.org/.

The key difference between the two types of rooftop garden learning programs is the scope of their educational focus. Programs built as one component of existing rooftop gardens are focused predominantly on educating students about environmental and nutrition issues for the sake of increasing environmental stewardship and community involvement. While projects built with the primary purpose of education are focused on these same issues, they also prioritize advancing academic outcomes by integrating hands-on learning into a wide array of school subjects.

The Unique Advantages of Rooftop Gardens

The advantages of garden-based education programs hosted on roofs extend far beyond those of traditional ground-level growing operations. In addition to the promotion of healthier diets, environmental awareness, and developmental benefits, garden-based education programs hosted on rooftops have additional social, environmental, and economic value. Rooftop gardens have social benefits as they provide a peaceful oasis in the middle of a crowded, bustling city. They also deliver economic value to the buildings on which they exist by increasing property worth and reducing heating and cooling costs. Lastly, rooftop gardens directly support the environment through improvements to air quality and reductions in combined sewage overflow and the urban heat island effect.

Social benefits of garden-based education programs on rooftop farms specifically are the peacefulness and heightened student engagement they provide. A notable quality of rooftop farms and gardens is their quietness as they are above the day-to-day disturbances of urban life. They provide an oasis from the traffic, loud noises, and dust that dominate city streets. Rooftop gardens, which through their stillness are more akin to the natural world than ground-level urban

growing projects, allow children to more fully recognize nature without as many distractions. Additionally, the novelty of rooftop gardens helps generate excitement among children, making them eager to engage with them.[116]

Rooftop gardens can also contribute economic benefits to the buildings on which they operate. First, as an attractive development, they increase a building's property value.[117] They also help protect the waterproofing materials on a roof from degradation caused by exposure to sunlight and temperature changes.[118] Furthermore, they act as thermal insulation, which creates a more energy efficient building.[119] In hot temperatures, the vegetation of the gardens has a cooling effect on the building's internal temperature. In cold temperatures, the garden has the opposite effect and helps keep the inside of the building warm. One study of a green roof in Madrid conveyed these effects as it found that the vegetated rooftop area led to savings of up to 25% of the cooling load in the summer.[120] These impacts allow building residents to save money on heating and cooling.[121] Through the advancement of energy efficiency, rooftop gardens also have a positive impact on the environment.

In addition to contributing to the environment through the promotion of environmental stewardship among the youth, rooftop educational gardens can have their own direct, positive impact. Like other urban growing projects, they help increase levels of biodiversity in the area and improve air pollution. By absorbing carbon dioxide and releasing oxygen, plants play an important role in maintaining air quality. In heavily populated and congested cities where

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[116] If the goal of spreading rooftop education gardens is realized and rooftop gardens are no longer novel, then this benefit will become less relevant.
[117] "About Green Roofs."
[118] Osmundson, Roof Gardens: History, Design, and Construction.
[119] Matthew Mosk, "As Green Disappears, Some Look Skyward; Arundel, Arlington Tout Benefits of Roof Gardens," *The Washington Post*, July 18, 2002.
[120] Orsini et al., *Rooftop Urban Agriculture*.
[121] Ibid.

available space for plants is limited, air pollution is even more magnified. Rooftop gardens play an especially important role in serving as space for plant growth that would otherwise not exist.

Rooftop gardens also support the environment by helping lessen the urban heat island effect, which occurs when there is a high prevalence of non-porous, dark surfaces and a lack of vegetation.[122] These surfaces, specifically black tar rooftops, absorb sunlight during the day and emit it at night, which prevents the city from cooling down.[123] The resulting urban heat island effect has negative consequences for the wellbeing of people living in cities as it can cause heatwaves that lead to serious health issues and can even result in death. The effect also requires a demand for more energy to cool buildings and leads to an increase in water usage.[124] When rooftops are covered with green space, they absorb less heat, which can reduce the extent to which the urban heat island effect impacts cities.

Unique from other forms of urban agriculture, rooftop growing can mitigate the negative effects of stormwater runoff and combined sewage overflow (CSO).[125] CSOs occur when the rainwater runoff, domestic sewage, and industrial wastewater collected by combined sewage systems exceed the volume capacity of the CSO treatment plant. They are a major environmental and public health concern as they contaminate waterways with raw sewage.[126] Rooftop farms, by collecting stormwater runoff, can prevent CSOs from occurring. In New York City, which has the greatest levels of stormwater runoff and CSO in the country, rooftop gardens and farms are

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[122] Abbas Mohajerani, Jason Bakaric, and Tristan Jeffrey-Bailey, "The Urban Heat Island Effect, Its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete," *Journal of Environmental Management* 197 (July 15, 2017): 522–38, https://doi.org/10.1016/j.jenvman.2017.03.095.
[123] "Sustainability," Brooklyn Grange, accessed March 25, 2019, https://www.brooklyngrangefarm.com/sustainability-1/.
[124] Mohajerani, Bakaric, and Jeffrey-Bailey, "The Urban Heat Island Effect, Its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete."
[125] Knott, "Brooklyn Grange Tour."
[126] John Tibbetts, "Combined Sewer Systems: Down, Dirty, and Out of Date," *Environmental Health Perspectives* 113, no. 7 (July 2005), https://doi.org/10.1289/ehp.113-a464.

especially important in supporting environmental health.[127] Between their two rooftops, The Brooklyn Grange alone is estimated to manage a combined two million gallons of stormwater per year, which allows for the lessening of concerns related to CSOs.[128]

Along with the value that they add to their communities, rooftop gardens avoid some of the challenges that their ground-level counterparts face. Soil in urban environments often contains pollutants like lead, which can contaminate the vegetables grown on that land. In Boston, for example, 88% of urban gardens had lead concentrations above the remediation threshold set by the U.S. Environmental Protection Agency.[129] If consumed, contaminated produce can have detrimental effects on human health. Because roofs do not have native soil, rooftop gardening requires the acquisition of soil from external sources, which allows the avoidance of these issues related to soil contamination.

Practical Considerations

Although rooftop garden educational programs are beneficial for both the communities in which they exist and the individual students who engage in them, there are many steps that need to be taken, which include overcoming several barriers, in order to develop them. Rooftop growing operations face many distinct challenges that are unique from traditional ground-level farms. There are relatively high startup costs, infrastructure barriers, accessibility and safety challenges, and bureaucratic requirements associated with roof gardens. Annie Novak, the founder of Eagle Street Rooftop Farm, recognized the steep learning curve that comes with

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[127] Danielle Berger, "A GIS Suitability Analysis of The Potential for Rooftop Agriculture in New York City" (Master's Thesis, Columbia University, 2013).
[128] "Sustainability."
[129] Steve Hallett, Lori Hoagland, and Emily Toner, "Urban Agriculture: Environmental, Economic, and Social Perspectives," *Horticultural Reviews*, September 2016, 65–120, https://doi.org/10.1002/9781119281269.ch2.

rooftop gardening. She summarized the challenges by stating, "Rooftop gardening requires permission, practicality, and patience with both your plants and local policy."[130] So while rooftop space in cities is widely available and may be leveraged as space for garden education, it is important to consider these specific challenges and ways to address them in addition to the barriers that affect garden-based education programs in general.

First, rooftop gardens require a high level of structural support to ensure that the building can withstand the weight of the growing operation. A cubic foot of fully saturated green roof weighs between sixty and eighty-five pounds.[131] Though the weight varies based on the agricultural model and design of the garden, structural support is nonetheless a make or break factor in whether a school can feasibly host a rooftop garden. Structural requirements are one of the most difficult challenges to overcome since it is simply not possible to develop growing operations on buildings that do not have the structural capacity for them without adding additional, and expensive, support structures. During their search for a roof to host their massive growing operation, the Brooklyn Grange found that old buildings like manufacturing centers or warehouses tend to be better suited for them. This is because buildings used to be constructed with a continuous frame from the ground up made of concrete-encased structural steel and densely spaced columns. A prewar construction date is generally a good indication of a strong support structure, while buildings erected more recently have a lessened structural capacity.[132] The typical building, according to Brad Rowe of Michigan State University, can only hold up to

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[130] Annie Novak, "Grow Up! How to Transform Your Roof into a Garden or Farm," Civil Eats, April 1, 2016, https://civileats.com/2016/04/01/grow-up-how-to-transform-your-roof-into-a-garden-or-farm/.
[131] Orsini et al., *Rooftop Urban Agriculture*.
[132] Plakias, *The Farm on the Roof: What Brooklyn Grange Taught Us About Entrepreneurship, Community, and Growing a Sustainable Business.*

five inches of soil.[133] Although school gardens do not require the same structural fortitude that multi-acre farms do, structurally sound roofs are a necessity for any rooftop growing operation. This requirement limits the schools that are even eligible to host garden-based education programs on their roofs.

Another major barrier to starting rooftop farms is the high costs associated with them. The startup costs of rooftop gardens are typically much greater than those of their ground-level counterparts. Starting a rooftop garden first requires the consultation of a structural engineer in order to determine whether a roof is suitable for the weight of a growing operation. The costs of the implementation process itself vary depending on the building and garden design. Factors such as the current configuration of the roof, proximity of water supply, and garden design structures all influence the cost of the garden.[134] A garden making use of temporary infrastructures such as garden beds and potted plants require significantly less startup capital than one utilizing formal rooftop agriculture methods that necessitate multiple layers of roofing. One analysis of container-based rooftop gardens found that the cost of materials per square foot of growing space amounted to $15.50. According to this estimate, the cost of materials alone for a one-quarter acre rooftop garden total to $168,795.[135] Less obvious factors that affect the overall cost include the prepping of the roof for proper drainage and waterproofing, the configuration of connections to a water supply, and the equipment required for installation.[136] Though an extreme example, Fifth Street Farm cost a total of $1 million to build. The Brooklyn

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[133] Jared Green, "Farm the Rooftops," The Dirt, December 16, 2011, https://dirt.asla.org/2011/12/16/farm-the-rooftops/.
[134] Orsini et al., *Rooftop Urban Agriculture*.
[135] John B. Carnett, "Green Dream: Installing a Rooftop Garden," Popular Science, January 11, 2010, https://www.popsci.com/environment/article/2009-12/green-dream-installing-rooftop-garden.
[136] Rooftop garden installation requires the transportation of heavy materials, including soil and structural design elements up multiple stories. Some gardens utilize soil blowers to transport soil to the roof, while others use cranes.

Grange, which installed a large-scale, soil-based commercial operation cost less than a quarter of this, requiring a total of $200,000 in startup capital.[137] Still, $200,000 is no small amount considering the financial constraints that schools face.

Although rooftop gardens are removed from the ground-level pollutants in cities, they nevertheless face challenges related to seeding, soil, and drainage. Although the biogeochemical processes of rooftop gardens resemble those of ground-level agricultural ecosystems, many components of rooftop systems differ. This makes it difficult to apply the knowledge of traditional systems directly to rooftops.[138] Thus, rooftop gardening comes with a steep learning curve. It requires finding a proper soil mix that is lightweight, drains well, and meets the demands of vegetable yield and quality.[139] Additionally, the heightened exposure to wind contributes to the difficulty of maintaining nutrients in rooftop soil. The wind can also lead to the toppling of delicate seedlings, which necessitates additional staking and trellising.[140]

Issues related to safety and accessibility must also be evaluated to ensure that the wellbeing of students is maintained as they interact with rooftop gardens. Safety measures such as strong, sturdy fencing, non-slip surfaces, and adequate fire exits must be installed.[141] Working on roofs also involves more intense exposure to the sun so it is imperative that students wear skin protection like sunscreen, hats, and proper clothing. Finally, it is important to take steps towards making the rooftop learning garden regularly accessible to all students, including those with

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[137] Plakias, *The Farm on the Roof: What Brooklyn Grange Taught Us About Entrepreneurship, Community, and Growing a Sustainable Business.*
[138] Yoshiki Harada et al., "Biogeochemistry of Rooftop Farm Soils," *Urban Soils*, n.d., 275–94.
[139] Ibid.
[140] Lisa W. Foderaro, "To Find Fields to Farm in New York City, Just Look Up," *The New York Times*, July 11, 2012, https://www.nytimes.com/2012/07/12/nyregion/in-rooftop-farming-new-york-city-emerges-as-a-leader.html.
[141] "Food Growing in Schools Taskforce."

disabilities. This may prove especially difficult in buildings that do not have elevator access to the roof.

Lastly, there is red tape that exists within cities, especially those that are not as forward thinking when it comes to urban agriculture that presents another challenge to starting a rooftop garden. One must navigate bureaucratic barriers related to zoning restrictions and permitting requirements. Urban farms are only permitted under certain land-use designations. Even though rooftop agriculture operations technically work on the roofs of buildings rather than the land, they are generally placed into the same category as ground-level farms. Creating larger scale urban growing projects also involves acquiring permits from various governing bodies. Developing rooftop gardens on schools requires navigating and complying with these various requirements.

Implementing Educational Rooftop Gardens

Building out garden-based learning programs on roofs requires acquiring support in the form of backing by key stakeholders, policies, financial resources, and partner organizations. With these elements, educators may be able to achieve the difficult mission of cultivating environmental awareness and knowledge about food systems among the urban youth through rooftop school gardens.

Starting a school garden is not possible without a leading visionary who is willing to put in the work needed to make it happen. Although this is usually a parent or teacher at the school, these leaders can also be general community members like Alice Waters in the case of the Edible Schoolyard. In order to realize their goal of a school garden, the leader must get other stakeholders on board. For a garden-based learning program to be fully integrated into the school

curriculum, teachers and the principal must be supportive of the project. Furthermore, the school board must approve it and in urban areas, city government officials must also grant their approval.

In cities, the support of local government is especially important in the creation of rooftop gardens. Those spearheading the program development must generate buy-in from city officials so they may overcome barriers related to municipal regulations. Moreover, local policymakers who recognize the environmental value of green roofs and call for their installment may play an important role in garnering support for these projects. For example, New York City Councilman Rafael Espinal, a close partner of the Brooklyn Grange, has been advocating for a bill that would mandate the installation of green roofs on buildings throughout the city.[142] If passed, the bill would raise awareness of the positive environmental benefits of, and help generate support for, rooftop gardens.

Just as policymakers play a central role in encouraging the development of garden-based education programs, so too does money. This was made evident in 1995 when California's state school superintendent Delaine Eastin issued a mandate that every school have a garden. She claimed that her goal was to "create opportunities for our children to discover fresh food, make healthier food choices, and become better nourished."[143] Though her intentions were admirable, her attempt at reaching this goal ultimately failed. This was because no money had been devoted to helping teachers build out these programs. The acquisition of capital plays a particularly important role in educational rooftop gardens due to the high costs associated with them.

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[142] Plakias, *The Farm on the Roof: What Brooklyn Grange Taught Us About Entrepreneurship, Community, and Growing a Sustainable Business.*
[143] Robert C. Stebbins, *Connecting with Nature: A Naturalist's Perspective* (Arlington, VA: National Science Teachers Association, 2012).

Funding may be acquired through private donors and grants from national or local entities. Because school rooftop gardens fall into the category of garden-based learning programs and green urban infrastructure, they may seek grant funding that supports either. There are a multitude of national organizations that offer funding for school garden programs. For example, the United States Department of Agriculture provides up to $7.5 million in grant funding annually through the Farm to School Program.[144] School gardens may also take advantage of the financing for green infrastructure projects that often exist at the local level. For instance, in New York City, green infrastructure projects are supported by a 20-year $1.5 billion capital initiative to fund community-based projects across the city.[145] The maintenance of these gardens may be supported through the sale of produce and value-added goods as made evident by the program at Eastdale Collegiate.

Realistically, most city schools do not have the resources to independently install and maintain rooftop gardens. The schools that have successfully integrated them into their curriculum have had support through partnerships with community organizations. The Over-the-Rhine Foundation helped create the Rothenberg Rooftop Garden, FoodShare Toronto worked to build the rooftop garden at Eastdale Collegiate, and New York Sun Works played an instrumental role in installing a greenhouse on the roof of the Manhattan School for Children. These types of strategic partnerships provide financial resources, technical expertise, and human capital that rooftop garden programs require.

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[144] "Farm to School Grant Program," United States Department of Agricutlure, accessed March 25, 2019, https://www.fns.usda.gov/farmtoschool/farm-school-grant-program.
[145] "Governor Cuomo Announces Green New Deal Included in 2019 Executive Budget | Governor Andrew M. Cuomo," New York State, January 17, 2019, https://www.governor.ny.gov/news/governor-cuomo-announces-green-new-deal-included-2019-executive-budget.

Conclusion

Garden-based education programs are worth investing in to help mitigate the problems associated with childhood obesity and limited environmental awareness. Though they alone are not enough to fully address these issues, they can have a tangible impact on children's knowledge of nutrition, food systems, and the environment. The positive benefits that they have on other aspects of childhood development further their value. Although schools across the country should consider integrating gardens into their curriculum, the programs may be especially significant in cities where children do not have regular exposure to the natural environment. However, creating school gardens in urban areas is difficult due to issues related to pollution and a lack of available space. The available rooftop space in cities may be leveraged as one solution that provides numerous external benefits.

Integrating rooftop school gardens into the urban fabric would yield value to students, their communities, and the environment. To have a widespread and meaningful effect, rooftop gardens should be advanced and popularized. Though one isolated green roof is beneficial, in order to have a real impact on reducing the urban heat island effect and combined sewage overflows, it must be joined by others. Beth Hanson of the Brooklyn Botanical Garden touched on the potential of green roofs and rooftop gardens by stating, "Most of these roofs are high up and out of sight for all save a number of city dwellers, but as more and more are built, their benefits will accrue and be felt by everyone."[146]

The primary barrier to building out rooftop garden-based education programs is the financial resources that they require. The economic burdens of creating rooftop gardens are too high for schools to implement them without external funding. Schools that have been successful

[146] Beth Hanson, "Greening the Fifth Facade," in *Green Roofs and Rooftop Gardens* (Brooklyn, NY: Brooklyn Botanic Garden, 2012).

at installing them have had grant funding as well as strategic partners who assist with the installation and maintenance of the gardens. Community organizations thus play a pivotal role in allowing schools to benefit from garden-based learning programs. Without their support, along with advancement in rooftop growing methods in general, it is unlikely that an expansion of rooftop gardens to other city schools will materialize.

These programs require the combined efforts of many and their advancement necessitates more resources and research. Although studies have been conducted on the immediate outcomes of garden-based education, the long-term effects have not been fully explored because of the high costs of longitudinal studies. Understanding the long-term effects of these programs will allow educators to improve and expand them. Further knowledge about academic outcomes specifically may be particularly valuable due to the results-driven and test-focused ideals of the American education system. Additionally, though rooftop gardens have become more popular over the past few years, feasibility studies and a comprehensive examination of existing rooftop school garden programs may support their expansion. Ultimately, for school gardens to expand, more people need to recognize their value and begin investing in them.

Bibliography

"About | FoodShare." FoodShare. Accessed March 25, 2019. https://foodshare.net/about/.

"About Green Roofs." Green Roofs for Healthy Cities. Accessed March 25, 2019. https://greenroofs.org/about-green-roofs.

"About Us | Garden School Foundation." Garden School Foundation. Accessed February 23, 2019. http://gardenschoolfoundation.org/about-us/.

Azzarito, Amy. "From Babylon to Brooklyn: The History of Rooftop Gardens." Food52, March 2, 2015. https://food52.com/blog/12407-from-babylon-to-brooklyn-the-history-of-rooftop-gardens.

Barnick, Anjali. "The Impact of a School Gardening Program on Nutrition Attitudes, Behaviors and Interests Amongst Fourth Grade Students." Cleveland State University, 2014.

Berger, Danielle. "A GIS Suitability Analysis of The Potential for Rooftop Agriculture in New York City." Master's Thesis, Columbia University, 2013.

Birch, L. L. "Development of Food Preferences." *Annual Review of Nutrition* 19 (1999): 41–62. https://doi.org/10.1146/annurev.nutr.19.1.41.

Bishaw, Alemayehu, and Kirby Posey. "A Comparison of Rural and Urban America: Household Income and Poverty." The United States Census Bureau, December 8, 2016. https://www.census.gov/newsroom/blogs/random-samplings/2016/12/a_comparison_of_rura.html.

Blair, Dorothy. "The Child in the Garden: An Evaluative Review of the Benefits of School Gardening." *The Journal of Environmental Education; Madison* 40, no. 2 (Winter 2009): 15–38.

"Brooklyn Grange Factsheet," n.d. https://static1.squarespace.com/static/569fd2b522482eeee4fcfa53/t/5a5fe40f71c10b8fa3bb553d/1516233743700/Brooklyn+Grange+-+fact+sheet+EPK.pdf.

Brown, Louise. "Eastdale Collegiate Opens Its Roof to Urban Agriculture." *The Star*, December 25, 2013. https://www.thestar.com/yourtoronto/education/2013/12/25/eastdale_collegiate_opens_its_roof_to_urban_agriculture.html.

Burns, Ryan, You Fu, Timothy Brusseau, Kristen Clements-Nolle, and Wei Yang. "Relationships among Physical Activity, Sleep Duration, Diet, and Academic

Achievement in a Sample of Adolescents - ScienceDirect." *Preventive Medicine Reports* 12 (December 2018): 71–74.

Burt, Kate G., Hersh B. Luesse, Jennifer Rakoff, Andrea Ventura, and Marissa Burgermaster. "School Gardens in the United States: Current Barriers to Integration and Sustainability." *American Journal of Public Health; Washington* 108, no. 11 (November 2018): 1543–49. http://dx.doi.org.libproxy.lib.unc.edu/10.2105/AJPH.2018.304674.

Carnett, John B. "Green Dream: Installing a Rooftop Garden." Popular Science, January 11, 2010. https://www.popsci.com/environment/article/2009-12/green-dream-installing-rooftop-garden.

Cason, Katherine L. "Children Are 'Growing Healthy' in South Carolina." *Journal of Nutrition Education* 31, no. 4 (July 1, 1999): 235–36. https://doi.org/10.1016/S0022-3182(99)70446-2.

"Child Population: Number of Children (in Millions) Ages 0–17 in the United States by Age, 1950–2017 and Projected 2018–2050." ChildStats.gov: Forum on Child and Family Statistics. Accessed April 1, 2019. https://www.childstats.gov/americaschildren/tables/pop1.asp.

"City Growers." Accessed March 25, 2019. https://citygrowers.org/.

Cole, Elizabeth S. "An Experience in Froebel's Garden." *Childhood Education; Washington* 67, no. 1 (Fall 1990): 18–21.

Cook, John T., and Katie S. Martin. "Differences in Nutrient Adequacy among Poor and Non-Poor Children." Center on Hunger, Poverty and Nutrition Policy, Tufts University, 11 Curtis Ave, March 1995.

Cornforth, Kyle. "The Edible Schoolyard: How It Works and Lessons for Parents, Teachers, and Health Professionals." *Childhood Obesity; New Rochelle* 7, no. 4 (August 2011): 278–81. http://dx.doi.org.libproxy.lib.unc.edu/10.1089/chi.2011.0400.expt.

Craul, Phillip J. "Urban Soil: Problems and Promise." *Urban Soils*, n.d., 23–32.

Cross, Bridget Ann. "The Impact of a School Garden and Environmental Education on the Environmental Awareness of Fifth Graders." M.A., Southeastern Louisiana University, 2013. http://search.proquest.com/docview/1354473402/abstract/BB239503E30D42E0PQ/1.

Darville, Sarah. “With Rooftop Garden Designed By ‘Starchitect,’ Earth School Branches Out.” The Local East Village, June 20, 2012. http://localeastvillage.com/2012/06/20/green-roof-comes-to-local-school-thanks-to-high-profile-architect/.

Dyg, Pernille, and Karen Wistoft. “Wellbeing in School Gardens – the Case of the Gardens for Bellies Food and Environmental Education Program.” *Environmental Education Research* 24, no. 8 (May 10, 2017): 1171–91.

Earl, Shyla A, and Erin Heinitz. “Urban Adolescent Women and Urban Nature: A Phenomenological Inquiry of the Human-Nature Relationship,” 2017. https://sophia.stkate.edu/ma_hhs/12.

“Edible Schoolyard Berkeley.” The Edible Schoolyard Project. Accessed February 22, 2019. https://edibleschoolyard.org/berkeley.

“Farm to School Grant Program.” United States Department of Agriculture. Accessed March 25, 2019. https://www.fns.usda.gov/farmtoschool/farm-school-grant-program.

“Farm to School Works to Make Gardens Grow.” The Farm to School Census. Accessed February 22, 2019. https://farmtoschoolcensus.fns.usda.gov/farm-school-works-make-gardens-grow.

“Fifth Street Farm: A NYC Public School Green Roof Project.” Accessed March 25, 2019. http://www.5thstreetfarm.org/.

Florence, Michelle D., Mark Asbridge, and Paul J. Veugelers. “Diet Quality and Academic Performance.” *The Journal of School Health* 78, no. 4 (April 2008): 209–15; quiz 239–41. https://doi.org/10.1111/j.1746-1561.2008.00288.x.

Foderaro, Lisa W. “Schools Add In-House Farms as Teaching Tools in New York City.” *The New York Times*. Accessed March 25, 2019. https://www.nytimes.com/2012/11/24/nyregion/schools-add-in-house-farms-as-teaching-tools-in-new-york-city.html.

———. “To Find Fields to Farm in New York City, Just Look Up.” *The New York Times*, July 11, 2012. https://www.nytimes.com/2012/07/12/nyregion/in-rooftop-farming-new-york-city-emerges-as-a-leader.html.

“Food Growing in Schools Taskforce.” Garden Organic, March 2012. https://www.foodgrowingschools.org/resources/files/FGIS%20main%20report%20for%20www.PDF.

"Forecast on the Degree of Urbanization in the United States from 2000 to 2050." Accessed February 22, 2019. https://www.statista.com/statistics/678561/urbanization-in-the-united-states/.

German, Katie. "Urban Agriculture in Schools: Eastdale's Rooftop Market Garden." Webinar, n.d. https://www.evergreen.ca/tools-publications/urban-agriculture-in-schools-eastdales-rooftop-market-garden/.

"Gotham Greens." Accessed March 25, 2019. http://www.gothamgreens.com/.

"Governor Cuomo Announces Green New Deal Included in 2019 Executive Budget | Governor Andrew M. Cuomo." New York State, January 17, 2019. https://www.governor.ny.gov/news/governor-cuomo-announces-green-new-deal-included-2019-executive-budget.

Green, Jared. "Farm the Rooftops." The Dirt, December 16, 2011. https://dirt.asla.org/2011/12/16/farm-the-rooftops/.

Grimm-Rice, Jaime. "A Master's Research Project Presented to The Faculty of the College of Education Ohio University." Ohio University, 2011.

"Grow to Learn NYC." Grow To Learn. Accessed February 23, 2019. http://www.growtolearn.org/.

"Grow to Learn NYC: The Citywide School Gardens Initiative." Accessed February 23, 2019. https://www.grownyc.org/grow-to-learn.

Haapala, Eero A., Aino-Maija Eloranta, Taisa Venäläinen, Henna Jalkanen, Anna-Maija Poikkeus, Timo Ahonen, Virpi Lindi, and Timo A. Lakka. "Diet Quality and Academic Achievement: A Prospective Study among Primary School Children." *European Journal of Nutrition* 56, no. 7 (October 2017): 2299–2308. https://doi.org/10.1007/s00394-016-1270-5.

Hales, Craig M. "Prevalence of Obesity Among Adults and Youth: United States, 2015–2016," no. 288 (2017): 8.

Hallett, Steve, Lori Hoagland, and Emily Toner. "Urban Agriculture: Environmental, Economic, and Social Perspectives." *Horticultural Reviews*, September 2016, 65–120. https://doi.org/10.1002/9781119281269.ch2.

Hammond, Ross, and Ruth Levine. "The Economic Impact of Obesity in the United States." *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy* 3 (2010): 285–95. https://doi.org/10.2147/DMSOTT.S7384.

Hanson, Beth. "Greening the Fifth Facade." In *Green Roofs and Rooftop Gardens*. Brooklyn, NY: Brooklyn Botanic Garden, 2012.

Harada, Yoshiki, Thomas H. Whitlow, Nina L. Bassuk, and Jonathan Russell-Anelli. "Biogeochemistry of Rooftop Farm Soils." *Urban Soils*, n.d., 275–94.

Hayden-Smith, Rose. "Soldiers of the Soil: A Historical Review of the United States School Garden Army." University of California Davis, Winter 2006. https://ucanr.edu/sites/thevictorygrower/files/101531.pdf.

"Higher Ground Rooftop Farm." Farmland Access. Accessed March 25, 2019. https://farmlandaccess.org/higher-ground/.

Jordan, Catherine, Evangelina Orozco, and Amy Averett. "Emerging Issues in School, Family, & Community Connections." National Center for Family & Community Connections with Schools, 2001.

Kelley, Ken. "Alice Waters." *Mother Jones*, 1995.

Klein, Leigh. "Garden-Based Learning: A Look at Its Importance for Children." M.A., Prescott College, 2012. http://search.proquest.com/docview/1021050377/abstract/DC3E0732B120472CPQ/1.

Knott, Danielle. "Brooklyn Grange Tour." Brooklyn Grange, October 20, 2018.

Lohr, Virginia, and Caroline Pearson-Mims. "Children's Active and Passive Interactions with Plants Influence Their Attitudes and Actions toward Trees and Gardening as Adults." *HortTechnology* 15, no. 3 (July 2005). https://doi.org/10.21273/HORTTECH.15.3.0472.

Louv, Richard. *Last Child in the Woods: Saving Our Children From Nature-Deficit Disorder*. Algonquin Books, 2008.

Mandel, Lauren. *Eat Up: The Inside Scoop on Rooftop Agriculture*. Gabriola Island, BC: New Society Publishers, 2013.

McAleese, Jessica D., and Linda L. Rankin. "Garden-Based Nutrition Education Affects Fruit and Vegetable Consumption in Sixth-Grade Adolescents." *Journal of the American Dietetic Association* 107, no. 4 (April 2007): 662–65. https://doi.org/10.1016/j.jada.2007.01.015.

Mohajerani, Abbas, Jason Bakaric, and Tristan Jeffrey-Bailey. "The Urban Heat Island Effect, Its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete." *Journal of Environmental Management* 197 (July 15, 2017): 522–38. https://doi.org/10.1016/j.jenvman.2017.03.095.

Monteiro, Ternan. "Rousseau's Concept of Education," n.d. http://snphilosophers2005.tripod.com/ternan.pdf.

Morris, Jennifer L., and Sheri Zidenberg-Cherr. "Garden-Enhanced Nutrition Curriculum Improves Fourth-Grade School Children's Knowledge of Nutrition and Preferences for Some Vegetables." *Journal of the Academy of Nutrition and Dietetics* 102, no. 1 (January 1, 2002): 91–93. https://doi.org/10.1016/S0002-8223(02)90027-1.

Mosk, Matthew. "As Green Disappears, Some Look Skyward; Arundel, Arlington Tout Benefits of Roof Gardens." *The Washington Post*, July 18, 2002.

"National Children & Youth Garden Symposium." American Horticultural Society. Accessed February 22, 2019. https://www.ahsgardening.org/gardening-programs/youth-gardening/ncygs.

Novak, Annie. "Grow Up! How to Transform Your Roof into a Garden or Farm." Civil Eats, April 1, 2016. https://civileats.com/2016/04/01/grow-up-how-to-transform-your-roof-into-a-garden-or-farm/.

———. *The Rooftop Growing Guide: How to Transform Your Roof Into a Vegetable Garden Or Farm*. Ten Speed Press, 2016.

"NY Greenhouse Classroom." *Growing A Greener World*, July 8, 2013. https://www.growingagreenerworld.com/episode-401-rooftop-greenhouse-classroom/.

Orsini, Francesco, Marielle Dubbeling, Hank de Zeeuw, and Giorgio Gianquinto, eds. *Rooftop Urban Agriculture*. Cham, Switzerland: Springer International Publishing, 2017.

Osmundson, Theodore H. *Roof Gardens: History, Design, and Construction*. New York: W. W. Norton & Company, 1999.

"Our Programs | Garden School Foundation." Accessed February 23, 2019. http://gardenschoolfoundation.org/our-programs/.

"Our Schools | Garden School Foundation." Accessed February 23, 2019. http://gardenschoolfoundation.org/our-schools/.

"Our Story." The Edible Schoolyard Project. Accessed February 22, 2019. https://edibleschoolyard.org/about.

"Our Vision." Rothenberg School Rooftop Garden. Accessed March 25, 2019. http://www.rothenbergrooftopgarden.com/our-vision/.

Plakias, Anastasia Cole. *The Farm on the Roof: What Brooklyn Grange Taught Us About Entrepreneurship, Community, and Growing a Sustainable Business*. New York: Penguin Random House, 2016.

Poon, Linda. "The Mental-Health Benefits of Turning Vacant Lots Green." CityLab, July 30, 2018. https://www.citylab.com/environment/2018/07/the-healing-potential-of-turning-vacant-lots-green/566066/.

"Project Overview | NY Sun Works." New York Sun Works. Accessed March 25, 2019. https://nysunworks.org/the-greenhouse-project/project-overview/.

Robinson-O'Brien, Ramona, Mary Story, and Stephanie Heim. "Impact of Garden-Based Youth Nutrition Intervention Programs: A Review." *Journal of the American Dietetic Association* 109, no. 2 (February 2009): 273–80. https://doi.org/10.1016/j.jada.2008.10.051.

"Rothenberg Preparatory Academy Rooftop Garden." Over the Rhine Foundation, n.d. http://www.otrfoundation.org/Docs/Background%20Information%20-%20Rothenberg%20Rooftop%20Garden.pdf.

Skelly, Sonja, and Jennifer Bradley. "The Importance of School Gardens as Perceived by Florida Elementary School Teachers." *HortTechnology* 10, no. 1 (January 2000). https://doi.org/DOI: 10.21273/HORTTECH.10.1.229.

Soga, Masashi, Kevin J. Gaston, and Yuichi Yamaura. "Gardening Is Beneficial for Health: A Meta-Analysis." *Preventive Medicine Reports* 5 (November 14, 2016): 92–99. https://doi.org/10.1016/j.pmedr.2016.11.007.

Stand, Blaine, and Steven W. Peck. "2016 Annual Green Roof Industry Survey Executive Summary." Green Roofs for Healthy Cities, July 2017.

Stebbins, Robert C. *Connecting with Nature: A Naturalist's Perspective*. Arlington, VA: National Science Teachers Association, 2012.

Subramaniam, Aarti. “Garden-Based Learning in Basic Education: A Historical Review,” Summer 2002. https://littlegreenthumbs.org/wp-content/uploads/2018/02/GardenBasedLearninginBaseicEducation_4H.pdf.

“Sustainability.” Brooklyn Grange. Accessed March 25, 2019. https://www.brooklyngrangefarm.com/sustainability-1/.

Tibbetts, John. “Combined Sewer Systems: Down, Dirty, and Out of Date.” *Environmental Health Perspectives* 113, no. 7 (July 2005). https://doi.org/10.1289/ehp.113-a464.

Torrey, Barbara Boyle. “Urbanization: An Environmental Force to Be Reckoned With.” Population Reference Bureau, April 23, 2004. https://www.prb.org/urbanization-an-environmental-force-to-be-reckoned-with/.

“Urbanization Causes and Impacts.” National Geographic. Accessed March 25, 2019. https://www.nationalgeographic.com/environment/habitats/urban-threats/.

Waliczek, Tina M., and Jayne M. Zajicek. “School Gardening: Improving Environmental Attitudes of Children through Hands-on Learning.” *Journal of Environmental Horticulture* 17, no. 4 (January 1999). https://www.researchgate.net/publication/285477581_School_gardening_Improving_environmental_attitudes_of_children_through_hands-on_learning.

Wells, Nancy, Beth Myers, Lauren Todd, Karen Barale, Brad Gaolach, and Gretchen Ferenz. “The Effects of School Gardens on Children’s Science Knowledge: A Randomized Controlled Trial of Low-Income Elementary Schools.” *International Journal of Science Education* 37, no. 17 (November 30, 2015): 2858–78.

Wright, Richardson. *The Story of Gardening: From the Hanging Gardens of Babylon to the Hanging Gardens of New York*. New York: Dover Publications, 1934.

Wright, Whitney. “The Disparities between Urban and Suburban American Education Systems: A Comparative Analysis Using Social Closure Theory.” Department of Political Science Howard University, March 31, 2012.

“Young Growers Create Schools Marketplace Success.” Sustain: the alliance for better food and farming, October 18, 2017. https://www.sustainweb.org/news/oct17_school_market/.